MA 32: Focus Session: Magnetic Correlations in Mesoscopic Spin Structures

Organized by Naëmi Leo (Paul Scherrer Institut Villingen) and Laura Heyderman (ETH Zürich)

Mesoscopic magnetic systems offer a unique way to create and study novel functionalities, from controlling the way in which single nanomagnets interact to observing emergent thermal behaviour. This focus session aims to bring together scientists investigating coupling phenomena, field-driven behaviour, and magnetic correlations in mesoscopic magnetic systems fabricated by nanolithography or self-assembly.

Time: Wednesday 9:30–12:15 Location: HSZ 01

Invited Talk MA 32.1 Wed 9:30 HSZ 01
Collective modes in magnonic vortex crystals — •Guido Meier — Max-Planck Institute for the Structure and Dynamics of Matter, Luruper Chaussee 149 22761 Hamburg, Germany

Collective modes in stacked disks containing magnetic vortices are investigated by ferromagnetic resonance spectroscopy and scanning transmission X-ray microscopy. In laterally coupled arrangements it has been shown recently that memory-like writing processes are possible based on the excitation of the gyrotropic mode [1]. We make use of the vertical dimension in tailored vortex stacks that drastically increases possible storage densities. The dynamics of all binary states emergent in a stack of vortices are directly observed [2]. The size of the arrangements is increased step by step to identify the different contributions to the interaction between the vortices. These contributions are the key requirement to understand complex dynamics of three dimensional vortex crystals. Both vertical and horizontal coupling determine the collective modes. In-plane dipoles strongly influence the interaction between the disks in the stacks and lead to polarity-dependent resonance frequencies [3]. Weaker contributions discern arrangements with different polarities and circularities that result from the lateral coupling of the stacks and the interaction of the core regions inside a stack. [1] M. Hänze, C. F. Adolff, M. Weigand, and G. Meier, Phys. Rev. B 91, 104428 (2015) [2] M. Hänze, C. F. Adolff, S. Velten, M. Weigand, and G. Meier, Phys. Rev. B 93, 054411 (2016) [3] M. Hänze, C.F. Adolff, B. Schulte, J. Möller, M. Weigand, and G. Meier, Sci. Rep. 6, 22402 (2016)

Invited Talk MA 32.2 Wed 10:00 HSZ 01
Stability of interfacial Skyrmions, Solitons and Bound Monopoles: How to store Energy in topological magnetic Quasiparticles. — •Elena Vedmedenko — University of Hamburg, Germany

One of the most exciting recent developments in nanomagnetism concerns topologically non-trivial magnetic configurations acting as quasiparticles. Among these quasiparticle excitations are three- or two-dimensional magnetic skyrmions, one-dimensional topological helices and zero-dimensional monopoles, which can also be bound by one-dimensional Dirac strings. Once created, magnetic quasiparticles can only be erased with effort from a surface. This makes them valuable for the application in future data storage devices but also poses fundamental questions on the microscopic reasons for the topological stability. Here, analytical and numerical analyses are used to study the dynamics and life-times of skyrmions, topological helices and bound monopoles in continuous and structured magnetic thin films. Additional attention is paid to the interaction between magnetic quasiparticles. It is shown that the main reason for the enhanced stability is a dynamical behavior of an energy barrier rather than its height. Interactions between quasiparticles, e.g. in spin-ices, are defined by the characteristic tension-to-mass ratio proportional to the fine structure constant and lattice parameters. On the basis of this analysis, a theoretical concept of the energy storage at the nanoscale is proposed and compared with recent experiments.

Invited Talk MA 32.3 Wed 10:30 HSZ 01
Exploring the statistical physics of frustrated spin systems with artificial spin ice — •Ian Gilbert[1], Yuyang Lao[2], Sheng Zhang[3], Gia-Wei Chern[4], Robert Ilic[1], Daniel Pierce[1], Cristiano Nisoli[5], John Unguris[1], and Peter Schiffer[2] — [1]Center for Nanoscale Science and Technology, National Institute of Standards and Technology, Gaithersburg, MD USA — [2]Department of Physics and Frederick Seitz Materials Research Laboratory, University of Illinois at Urbana-Champaign, Urbana, IL USA — [3]Materials Science Division, Argonne National Laboratory, Argonne, IL USA — [4]Physics Department, University of Viriginia, Charlottesville, VA USA — [5]Theoretical Division and Center for Nonlinear Studies, Los Alamos National Laboratory, Los Alamos, NM USA

Arrays of nanomagnets known as artificial spin ice provide unique and valuable insight into the statistical physics of frustrated magnetism because the lattice geometry can be arbitrarily tuned and the exact configuration of the constituent magnetic moments can be directly imaged. Here I describe several recent studies of correlations and emergent phenomena in artificial spin ice with several new lattice geometries. First, the shakti lattice possesses an extensively-degenerate ground state analogous to natural spin ice materials as well as magnetic charge screening. Second, the tetris lattice exhibits reduced dimensionality and frustration-dependent thermal fluctuations. Finally, I will discuss ongoing efforts to investigate artificial spin ice with randomness built in to the island locations.

15 min. break

Invited Talk MA 32.4 Wed 11:15 HSZ 01
Skyrmions in [Pt/Co/Ir] multilayers at room temperature — •Katharina Zeissler[1], Simone Finizio[2], Jörg Raabe[2], Michal Mruczkiewicz[3], Philippa Shepley[1], Thomas Moore[1], Gavin Burnell[1], and Christopher Marrows[1] — [1]School of Physics and Astronomy, Leeds University, E.C. Stoner Building, Leeds, UK, LS2 9JT — [2]Paul Scherrer Institute, 5232 Villigen, Switzerland — [3]Institute of Electrical Engineering, Slovak Academy of Sciences, Dubravska Cesta 9, SK-841-04 Bratislava, Slovakia

Magnetic quasiparticles such as skyrmions are important objects in the quest for novel magnetic information storage. They have been observed in bulk materials as well as in multilayer systems. The latter has great scope for applications due to skyrmion stability at room temperature. The nucleation, manipulation and detection of skyrmions are active research areas. The focus of this talk will be skyrmion stabilisation and detection in [Pt/Co/Ir] multilayer nanodiscs and their manipulation via external stimuli such as external magnetic fields and current pulses. Chiral spin textures, including skyrmion bubbles, were stabilised in nanodiscs and imaged using scanning X-ray microscopy and their electrical response was measured in situ. This setup allowed for a direct comparison between the chiral magnetic state and its electrical transport signature. The influence of pinning due to stack imperfections was found to be of importance for skyrmion stabilisation.

Invited Talk MA 32.5 Wed 11:45 HSZ 01
Artificial magnets as model systems : from the fragmentation of magnetization to the seminal square ice model — •Benjamin Canals, Yann Perrin, Ioan Chioar, and Nicolas Rougemaille — Institut NEEL, Grenoble, France

Complex architectures of nanostructures are routinely elaborated using bottom-up or nanofabrication processes, allowing scientists to engineer frustrated arrays that do not exist in nature. These systems have been the subject of intense research in the last few years and have allowed the investigation of fascinating phenomena, such as the observation of pseudo-excitations involving classical analogues of magnetic charges. This talk aims at providing two examples of two-dimensional artificial magnets which allow to probe the low energy manifolds of two exotic Ising systems.

The first one is related to the seminal square ice model and shows that it is possible to perform a scan through the 6-vertex model phase diagram with an appropriately designed artificial magnet [1]. The second one refers to a recent proposal, the fragmentation of magnetization [2], in an Ising kagome model, which corresponds to the effective splitting of the local degree of freedom into two channels independent channels [3].

[1] Y. Perrin, B. Canals, N. Rougemaille, Nature 540, 410-413 (2016). [2] M. E. Brooks-Bartlett et al., Phys. Rev. X, 4, 011007 (2014). [3] B. Canals et al., Nat. Comm. 7, 11446 (2016).